Performance Measures

Introduction

Performance measures are indices that indicate how well an alternative achieves the objectives of the Bay-Delta Program. They can be used to evaluate alternatives and guide the development of new alternatives. Performance measures form, collectively, a "yardstick" to use in measuring how well an alternative achieves the objectives of the Bay Delta Program. In this report, we describe the process of developing and using performance measures in two sections: *Building the Yardstick*, and *Using the Yardstick.*

The performance measures described here are work in progress. They have not yet been fully reviewed by CALFED. The set described here does not include the solution principles, i.e., the program objectives concerned with aspects of the solution not directly related to the Mission Statement, such as equity, affordability and implementability.

Building the Yardstick

Step 1: Develop Performance Measures

Performance measures were directly derived from the mission statement and objectives of the Bay Delta Program. Figure 1 is an overview of the role and use of performance measures The top three rows of boxes in that figure frame how the performance measures fit into the higher-level objectives of the Bay Delta Program. The top box is the Mission Statement of the Program. The current wording of that statement (dated September 28, 1995) is: "To develop a long term comprehensive plan to restore ecological health and to improve water management for the beneficial uses of the Bay-Delta system." The next row of boxes is the set of four resource areas. (See the Bay Delta Program Public Workshop Information Package, Appendix A, dated December 4, 1995, for primary problem/objective statements for each of those areas.) The third row of the figure specifies the objectives of the Program associated with each resource area. Each performance measure is a measurable version of an objective. The eight performance measures presented in this report correspond to the objectives in the third row of the figure. The set of objectives, and so performance measures, has evolved through several steps in the Program. That process began in July, 1995, with the initial formulation of the Problem Definition and Problem Statements. That then evolved through sets of issues and objectives until the current set of eight, as presented in the figure. A one-page summary of each performance measure is included in the attached pages. A review of those pages will find a direct correspondence between the eight performance measures and the set of fourteen objective statements for the Program dated October 11. The reduction in number from fourteen to eight is the result of a logical regrouping of the objectives into forms more conducive for scoring alternatives.

Step 2: Develop Scoring Factors

Figure 2 is an overview of Steps 1 through 4, the steps that "build the yardstick." As that figure indicates, in Step 2, each performance measure is broken down into scoring factors. The attached pages graphically describe that breakdown. The scoring factors are elements of each performance measure that are more reliably scorable than the performance measure itself. At this stage in the project the performance of each alternative on each performance measure is based on expert judgment. That is, an expert was assigned to evaluate each action that could comprise an alternative by assigning a score for each scoring factor, using a process to be described in the next section. In order for that scoring to be as repeatable as possible, each scoring factor has to be as tightly specified as possible, given the level of generality of the actions to be evaluated. The attached pages describe those scoring factors. Note that for different performance measures, there are different logical breakdowns into scoring factors.

Step 3: Assign Proportion of Problem Associated With Each Scoring Factor

Each of the scoring factor boxes has a percentage associated with it. That number represents the proportion of the "problem" or "objective" associated with that box. For example, from the Aquatic Habitat page we see that the Aquatic Habitat "problem" is considered to be 75% in the Delta and 25% upstream of the Delta. In turn, of the Delta Aquatic Habitat problem, 20% is considered to be associated with transport, 20% associated with shaded and shallow areas, etc.

The geographic breakdowns for the habitat performance measures call for comment. The upstream scoring factors are not meant to imply that part of the evaluation of a Bay-Delta solution will be based on the delivery of upstream benefits from that solution. The objectives of the Bay-Delta Program do not include improving habitats upstream of the Delta. However, those scoring factors are included to reflect the fact that improvements in upstream habitat will provide benefits for Delta habitats and species. Thus the 75/25 and 80/20 weighting between Delta and upstream habitat factors does not imply that upstream habitat is somehow much less important than Delta habitats, but that measures involving upstream habitats only have indirect benefits for Delta habitats and species.

Step 4: Define Scales and Endpoints for Each Scoring Factor

The score on each scoring factor is the "proportion of the problem solved." That is, if an action solves ten percent of the transport problem of Delta Aquatic Habitat, then it receives a score of .10. For each scoring factor, two endpoints are defined. The "low" end is the existing condition. The "high" end is the maximum achievable benefit for the Bay-Delta Program. So the "proportion of the problem solved" represented by the score is the proportion of the distance from the existing condition to the maximum achievable benefit that the action moves the system. For example, as illustrated in Figure 2, the endpoints for the shallow & shaded area for Delta

Aquatic Habitat were estimated to be 20% of the natural state (low end, existing condition) and 80% of the natural state (high end, target condition, maximum achievable benefit). If an action would double the existing shallow and shaded area, from 20% to 40% of the natural state, it would be scored at .33 (the 20 %-point increase would be one third of the way along the full 60 %-point scale from 20% to 80% of the natural state).

Using the Yardstick

Step 5: Score Each Action on Each Scoring Factor

Figure 3 is an overview of the first two of the "using the yardstick" steps, Steps 5 and 6. As indicated in that figure, in Step 5 each of the 209 actions is scored against the 61 scoring factors. For example, an action is scored on the Aquatic Habitat measure by first scoring it on each of the eleven scoring factors for that measure. Each score, as just explained, is the "proportion of the problem solved," i.e., the proportion of the way the action moves the system from the existing condition to the maximum achievable benefit.

Step 6: Calculate Eight Performance Measure Scores for Each Action

For each action, each performance measure is calculated as a weighted sum of its corresponding scoring-factor scores. For example, the overall Aquatic Habitat score is calculated by summing its eleven scoring-factor scores, weighted by the percentages indicated on the attached pages, i.e., the "proportion of problem associated with each scoring factor." For example, the Transport score (the first one on the left for Aquatic Habitat) is multiplied by .15 (20% x 75%), while the Instream Flows score is multiplied by .10 (40% x 25%). The top three rows of numbers in Figure 1 are example scores for each action on each performance measure. Each of those numbers represents the weighted sum of the scores of the scoring factors for that performance measure.

Step 7: Approximate the Eight Performance Measures Scores for Each Alternative by the Sum of the Performance Measure Scores for the Actions that Comprise That Alternative

Steps 5 and 6 provide eight scores for each action, one score for each performance measure. Those steps, then, provide the table of numbers in the middle of Figure 1. The lower half of that figure is an overview of aSteps 7, 8 and 9. As indicated in that figure, Steps 7 and 8 combine the eight scores for each action into eight scores for each alternative. First, for each performance measure, the score for an alternative is approximated as the sum of the scores on that performance measure over all the actions that comprise that alternative.

Step 8: Adjust the Eight Performance Measure Scores for Each Alternative to Account for Interactions Among Actions

The sums from Step 7 may have to be adjusted to account for synergy, interference, flow balance, and other interactions. The interaction adjustments are to be limited to clearly anticipated levels of interaction, so that the quantitative content of the summed scores is retained. and not negated by subjective judgments of large interactions. As indicated in Figure 1, that summing and adjustment takes place at the performance measure level, so that the result is eight scores for each alternative.

Step 9: Combine Performance Measure Scores into Overall Evaluation Scores for Each Alternative, One Overall Evaluation Score for Each of Several Stakeholder Perspectives

It is desirable to evaluate each alternative with an overall score, so that alternatives can be compared, and guidance developed as to how to improve alternatives. However, the only way to derive a single overall score from the eight separate performance measure scores is to weight them and sum them (and perhaps do other calculations to represent interactions and desire for equity, that would also involve weights), again as indicated in Figure 1. Those weights, however, represent important value tradeoffs. For example, weights on these eight performance measures would include the relative weight to give aquatic habitat versus water supply. It is unlikely that the Bay-Delta Program could arrive at a single set of weights that would be satisfactory to all stakeholders.

Our solution to that problem is to elicit several sets of weights, one each from a panelist (or an entire panel) representing a particular set of value tradeoffs, or a "stakeholder perspective." Suppose we elicit four such perspectives. That would give us four different sets of weights, and so four "overall scores" for each alternative. We could then use those scores to rank alternatives, but of course we would have four different ranking of alternatives. Those four rankings are indicated in Figure 2.

The elicitation of weights must be done following a particular protocol in order to get defensible weights. We have already done one such trial elicitation. Only a partial elicitation was performed, but we did obtain preliminary relative ranking of weights. Using those rankings, we can approximate the numerical weights using a recently-developed technique (the "Barron approximation"). Numerical weights can be directly elicited, with more panel time. The following table presents preliminary weight rankings for the four perspectives elicited. These rankings are presented simply to establish that we were able to obtain the weight rankings. In practice, the rankings would be subjected to several consistency checks, and could very well change substantially from the rankings reported here.

Ecology	Fisheries	Urban	In-Delta
Aquatic Habitat	Aquatic Habitat	Water Supply	Vulnerability
Species of Int.	Species of Int.	Drinking WQ	Water Supply
Water Supply	Wetlnd/Uplnd	Water Uncert.	Drinking WQ
Wetlnd/Uplnd	Drinking WQ	Vulnerability	Aquatic Habitat
Drinking WQ	Ag/Ind WQ	Ag/Ind WQ	Ag/Ind WQ
Vulnerability	Water Uncert.	Aquatic Habitat	Water Uncert.
Water Uncert.	Water Supply	Wetlnd/Uplnd	Wetlnd/Uplnd
Ag/Ind WQ	Vulnerability	Species of Int.	Species of Int.

The actual significance of these rankings can only be communicated by also presenting the endpoints on each performance measure. For example, the fact that the urban perspective elicited here ranks drinking water quality as less important than water supply is entirely dependent on the relative ranges from low to high (i.e., from existing condition to maximum achievable benefit) on those two performance measures. If the water supply range were greatly decreased, the same respondent would rank drinking water quality as more important than water supply.

Step 10: Evaluate Each Alternative by Considering All Stakeholder Perspectives

Steps 1 through 9 provide us with the means to rank the alternatives by how well each achieves the objectives of the Bay-Delta Program, with one ranking for each stakeholder perspective, as presented in Figure 4. We can then evaluate each alternative by combining the several stakeholder-perspective evaluations. There are several ways to do that combination. One way is to assess each alternative's "breadth of support," i.e., how highly it is ranked across the different stakeholder perspectives. For example, in Figure 4 we see that Alternative 25 could be promising because it ranks in the top four for all four perspectives. Another way would be to use the rankings to simulate how majority-rule voting would rank the alternatives (though one complication is that in some cases, the outcome of a series of majority-rule votes can be affected by the order in which those votes are taken). A third way to combine the evaluations is by the "Rawls Criterion," which is simply to evaluate an alternative by how well it scores on the stakeholder perspective least well served by that alternative. For example, from Figure 4, if Alternative 25 scores most poorly for Stakeholder Perspective D, then it is assigned that score overall. Another way to combine the evaluations is simply to add the scores across stakeholder perspectives, with equal weighting among them. Both of the last two scoring methods involve some technical choices regarding rescaling. In practice, it is usually desirable to simply do all of the above four methods, and deliver all of those results, including the separate rankings by stakeholder perspective, as indicated in Figure 4. The decision making process can then take all of those considerations into account in determining which alternatives are to be retained, and how those alternatives are to be developed and refined.

Next Steps:

1. Apply the performance measures to alternatives as they are developed, and use those to guide decisions for developing and refining alternatives.
2. Develop guidance for selecting actions to add to and delete from an alternative in order to improve it.
3. Develop and score an affordability performance measure.
4. Develop and score performance measures reflecting the Solution Principles of the Program.
5. Refine the endpoints for each performance measure.
6. Refine the actions scores as the actions are refined.

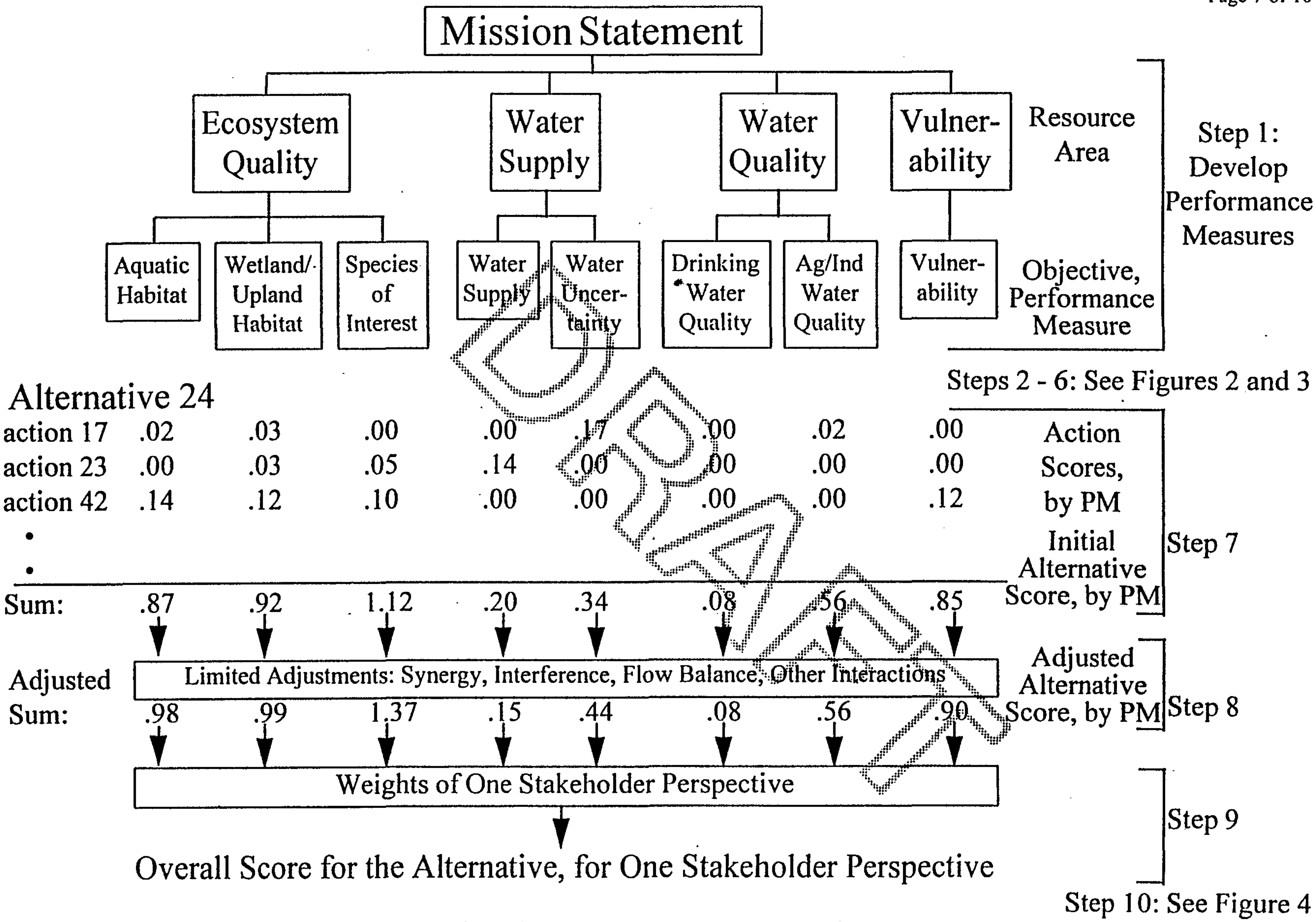


Figure 1. Overview of performance measures and scoring

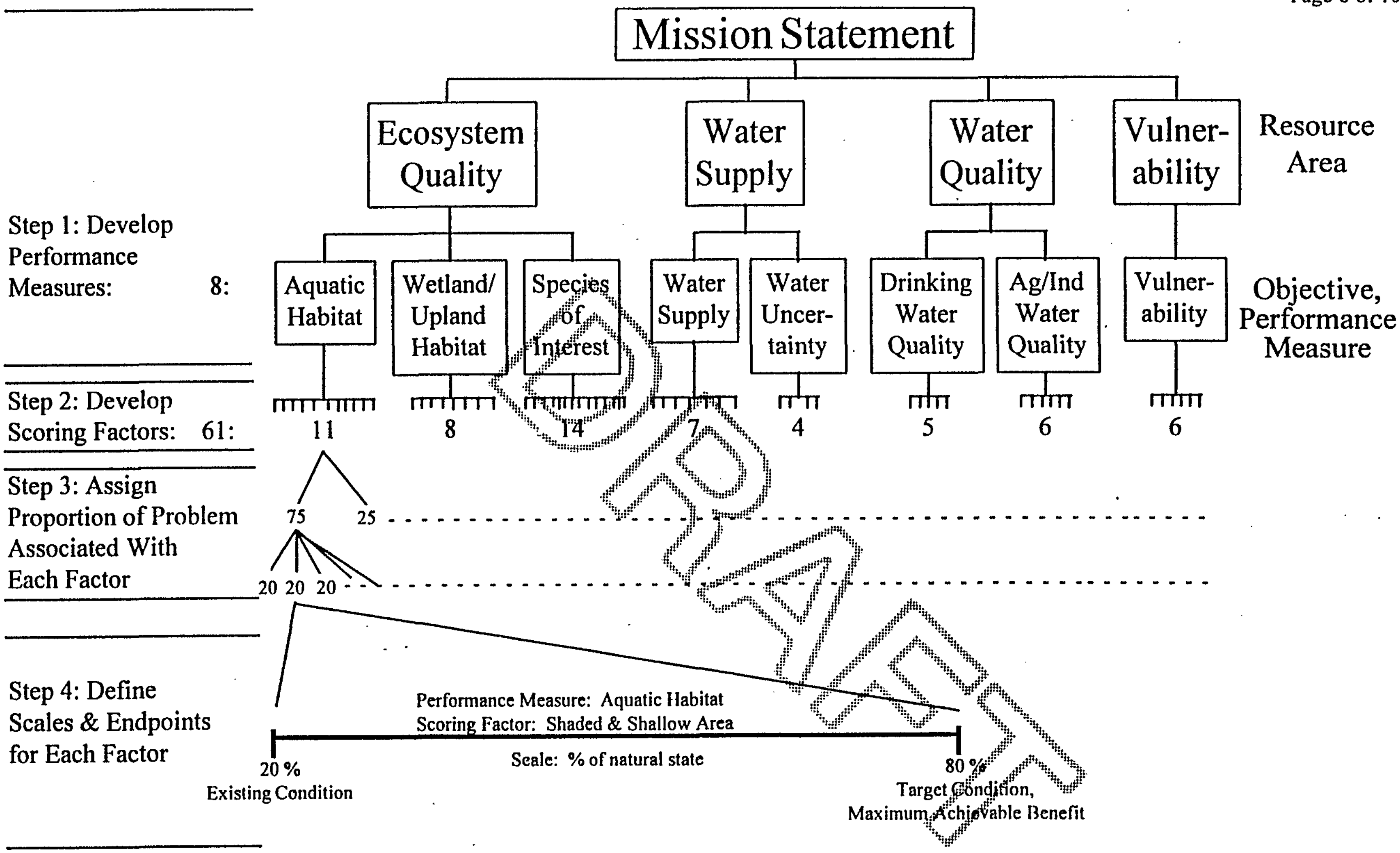


Figure 2. Steps 1 through 4: Building the Yardstick, from Mission Statement to scales and endpoints for each scoring factor.

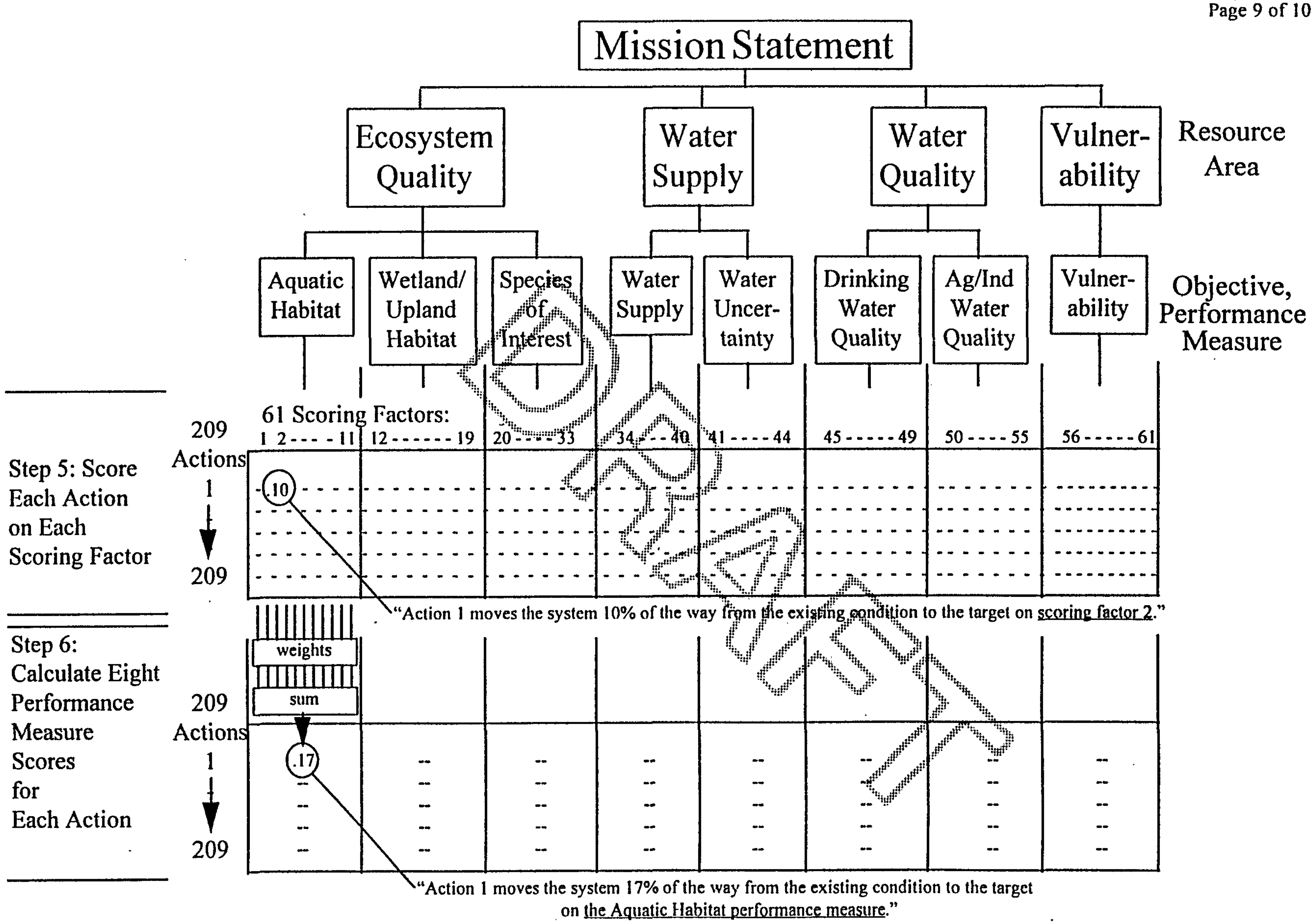


Figure 3. Steps 5 and 6: Using the Yardstick, scoring actions: first by scoring factors, then by performance measures.

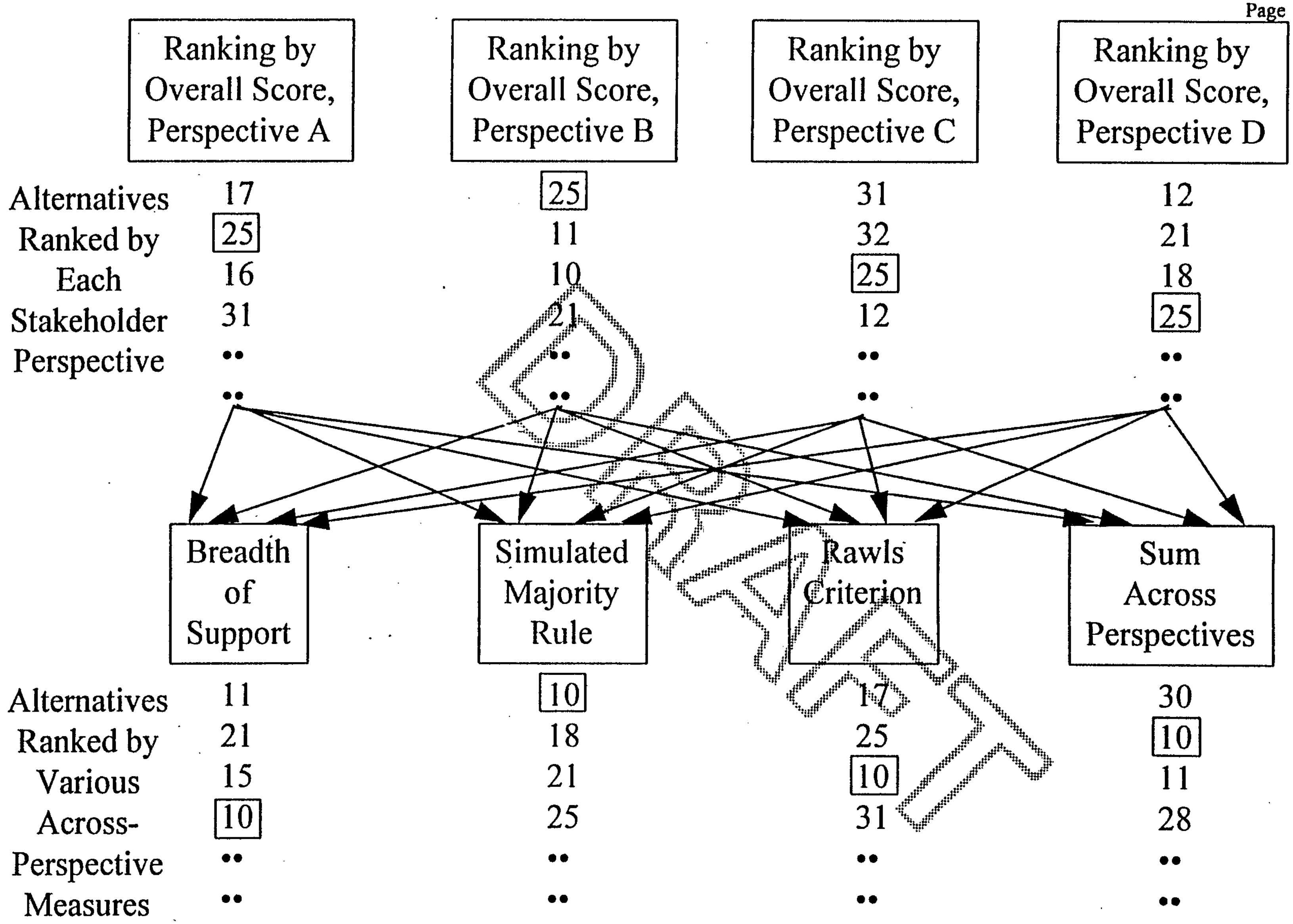
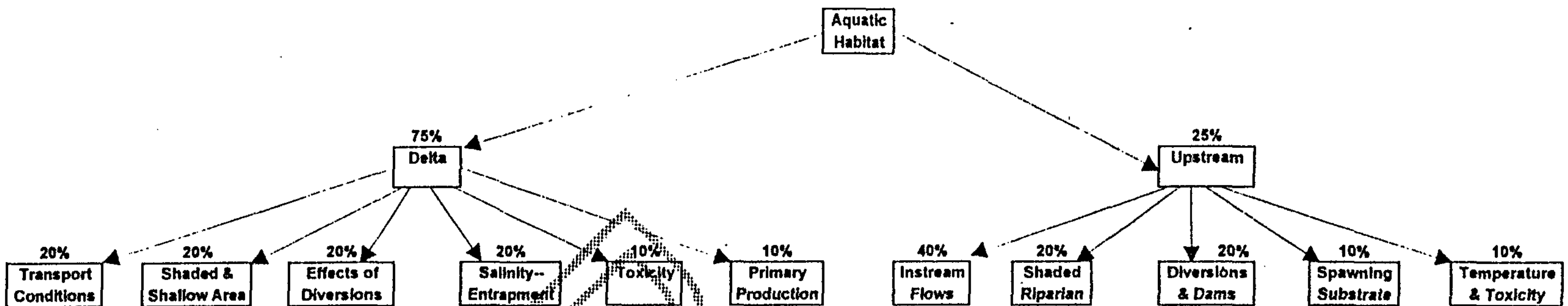


Figure 4. Step 10: Evaluate each alternative by considering all stakeholder perspectives.

Performance Measure: Aquatic Habitat

Objective: **Improve and Increase Aquatic Habitats so that they can support the sustainable production and survival of native and other desirable estuarine and anadromous fish *in the estuary*.**



This performance measure reflects the degree to which the alternative provides suitable aquatic habitat protection and restoration for the Bay-Delta ecosystem processes and populations of organisms.

Geographic Areas

The potential to successfully achieve the maximum aquatic habitat benefits has been allocated between the Delta and upstream geographic areas. Upstream benefits are weighted at 25% to reflect the fact that they should be credited only for the indirect in-Delta benefits that they provide.

Scoring Factors

Delta habitat include:

Transport Conditions. River inflows and Delta channel flows necessary to move fish from spawning to rearing habitat and to prevent the movement (or migration) of fish away from preferred habitat (or migration pathway).

Shaded & Shallow Area. This factor includes the shallow and protected tidal water adjacent to Delta channels or at the perimeter of open water embankments. Riparian vegetation increases the value of the shallow area as spawning and rearing habitat.

Effects of Diversions. This factor evaluates actions that reduce the existing effects of diversions from PG&E powerplants, Delta water supply siphons and pumps, as well as pumping for CVP and SWP exports. Entrainment is considered to be a loss of habitat value. Reduced entrainment increases the habitat value for estuarine and anadromous fish rearing in the Delta.

Salinity Entrapment. This factor evaluates benefits from actions that contribute to optimal location of the salinity gradient and provide improved estuarine habitat conditions.

Toxicity. This component evaluates benefits from actions that reduce the duration and magnitude (severity) of toxic concentrations of agricultural and industrial chemicals.

Primary Production. This factor includes general conditions necessary to support shallow aquatic habitat productivity (food-web dynamics). This includes growth factors (nutrients and light) as well as control of aquatic plants or "clams" that limit food-web productivity for species of interest.

Upstream habitat include:

Instream Flows. This factor includes streamflows that are necessary to fully support spawning, rearing, and downstream migration of anadromous fish.

Shaded Riparian. This factor includes the physical channel and riparian vegetation factors that contribute to instream habitat. (These distinguish a stream from an irrigation canal.)

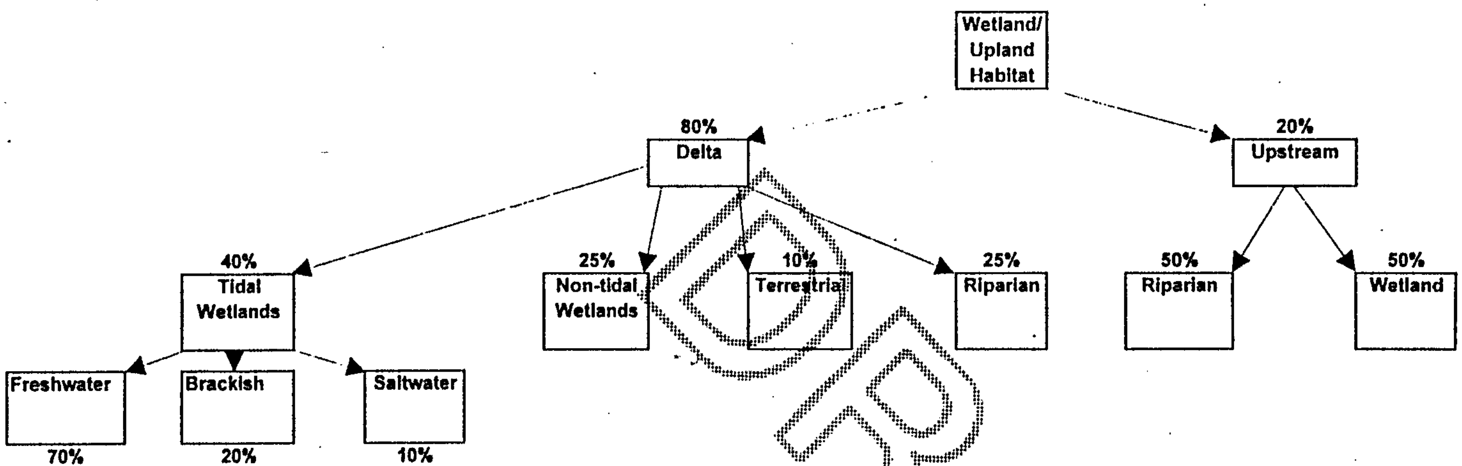
Diversions & Dams. This component evaluates actions that control or eliminate the negative effects of dams and diversions along a stream that limit migration and rearing conditions.

Spawning Substrate. This factor includes the necessary gravel conditions (size, flushing of fines) for optimum spawning within a stream.

Temperature and Toxicity. This factor evaluates actions that reduce the duration and magnitude of toxic concentrations of chemicals and that control or eliminate deleterious temperatures with a stream reach.

Performance Measure: Wetland/Upland Habitat

Objective: **Improve and increase important Delta habitats so that they can support the sustainable production and survival of wildlife species.**



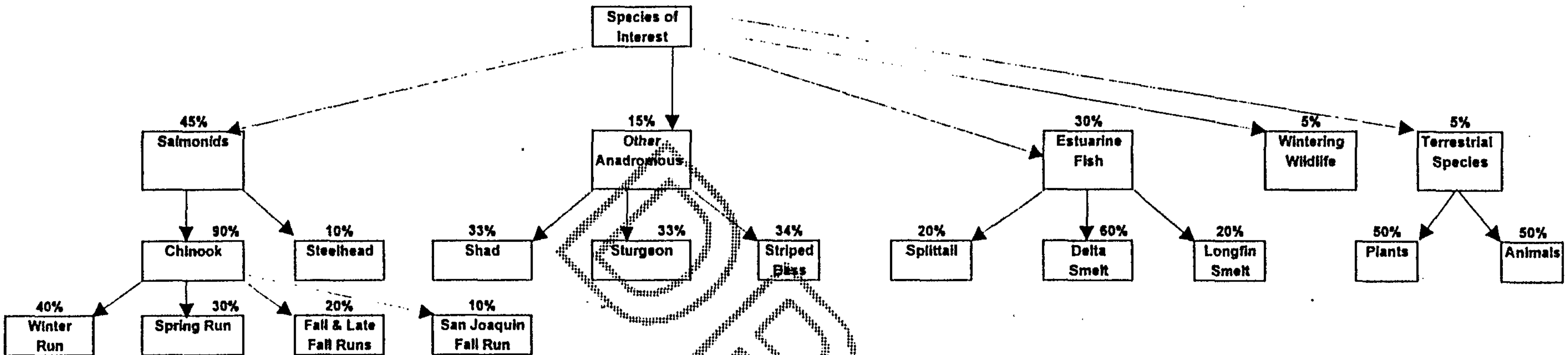
This performance measure reflects the degree to which an alternative meets ecosystem quality objectives for wetland habitats to support wildlife species.

Geographic Area
Habitat improvements can occur in the Delta and upstream of the Delta, though upstream benefits should be credited only for the indirect in-delta benefits that they provide.

Scoring Factors
Delta Freshwater Tidal Wetlands. This component evaluates how well an action improves or increases Delta freshwater marsh. This component recognizes benefits that restore and improve salinity levels; increase the aerial extent; and improve the connectivity of marsh habitat with open space/habitat areas.
Delta-Suisun Brackish Tidal Wetlands. This component recognizes benefits that modify salinity levels to improve vegetation composition; increase the aerial extent of brackish marsh; and improve connectivity with other open space/habitat areas.
Delta Saltwater Tidal Wetlands. This factor evaluates how an action impacts Delta saltwater wetlands.
Delta Non-Tidal Wetlands. This component evaluates how well an action improves and increases in-Delta non-tidal marsh habitats, including both seasonal and perennial wetlands for waterfowl and other species. This component recognizes actions that increase the amount of breeding waterfowl habitat; increase the amount of wintering habitat for waterfowl and shorebirds; and increase the amount of managed permanent pasture for sandhill cranes.
Terrestrial Habitat. Within the Delta, terrestrial habitat includes upland transitional areas, natural upland areas and unnatural or modified land-forms that provide important wildlife habitat, including cropland, fallow fields, pastures, and levees. This component recognizes actions that increase upland habitat or make improvements to existing habitat, including clean-up of toxic sites and implementation of wildlife friendly agricultural practices.
Delta Riparian Habitat. This component recognizes actions that reduce habitat fragmentation, increase the aerial extent of riparian habitat, and/or improve the connectivity of riparian habitat to other wildlife habitats.
Upstream Riparian Habitat. This component recognizes actions that reduce habitat fragmentation, increase the aerial extent of riparian habitat, and/or improve connectivity.
Upstream Wetland Habitat. This component recognizes actions that increase the amount of breeding waterfowl habitat, increase the amount of upstream wintering habitat for waterfowl and shorebirds; increase the amount of managed permanent pasture for sandhill cranes; increase the aerial extent of wetland habitat; and improve connectivity.

Performance Measure: Species of Interest

Objective: **Increase population health and population size of Delta species to levels that assure recovery and provide sustainable population size.**



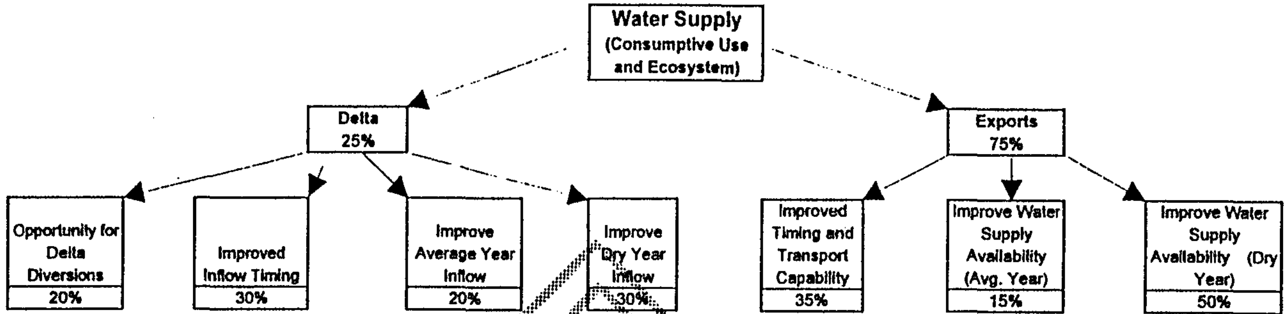
This performance measure reflects the degree to which the alternative provides species-specific stock management and habitat protection or restoration actions that are likely to increase the population of the species of interest. Because the likely benefit of an action will vary with the species, separate benefit factors for 13 species or groups are identified for rating.

Geographic Area.
The geographic area of interest is dependent on the life history of each species of interest. Both salmonids and other anadromous fish spend portions of their life history is the ocean, in the Bay Delta, and in upstream tributary streams. Estuarine fish spend more of their life-history in the Bay-Delta. Wintering wildlife and terrestrial species may remain in the Bay-Delta or may migrate through the Bay-Delta.

Scoring Factors.
Scoring factors were not separately distinguished, but instead follow the type of species. Habitat protection or restoration actions that provide general aquatic or wetland habitat benefits will be rated in the aquatic habitat performance measure. However, if the habitat management action is expected to directly benefit one of the important species, then additional credit will be given in the species of interest performance rating.

Performance Measure: Reduce Water Supply Conflicts

Objective: Reduce the conflict between beneficial water users and improve the ability to transport water through the Bay-Delta System.



This performance measure reflects the degree to which the alternative reduces the conflict between beneficial water users in the Bay-Delta system and the degree to which transport capability through the Delta is improved both by capacity and timing.

Geographic Areas

The potential to successfully reduce the conflict between the beneficial water users of Bay-Delta water supplies can be divided between the Delta and the export areas and measured separately.

Scoring Factors

Opportunity for Delta Diversions: Diversion opportunities in the Delta often are restricted due to ecological or water quality reasons. Improvements for diversion opportunities within the Delta would include added multiple diversion points, consolidation of existing diversion points, and improvements for areas such as South Delta.

Improved Delta Inflow Timing: Delta inflow timing within the year is often restricted due to upstream operations centered around single-purpose needs and limited water resources. Improvements could be made through the reoperation of existing facilities.

Improve Average Year Delta Inflow: Increased average year Delta inflows would increase opportunities for multiple uses including potential ecosystem enhancements while not shorting consumers. Inflow could be increased with added upstream storage as well as any other action that would generate water supplies.

Improve Dry Year Delta Inflow: Increased dry year Delta inflows would reduce conflicts between potentially short consumers and an already stressed ecosystem. Inflows could be increased through added storage, increased conjunctive use operations, further conservation, land fallowing, and reduced upstream diversions.

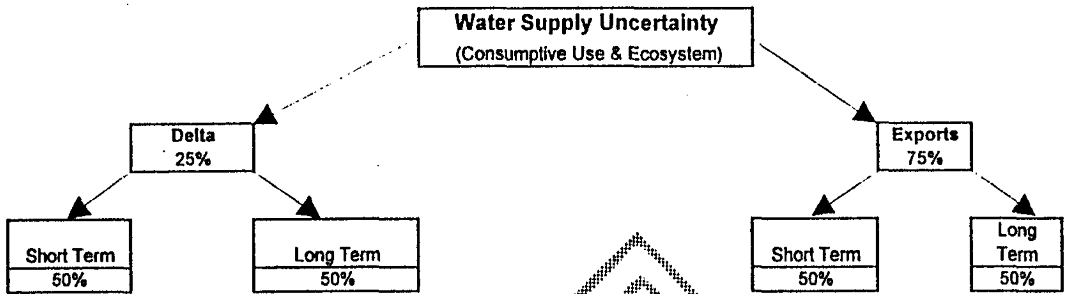
Improved Timing and Transport Capabilities for Exports: Delta exports are often impaired by the timing of water reaching the Delta along with the Delta transport capability. Improved transport capability would allow the movement of more water south in wet years while minimizing the potential for fishery entrainment. Improved timing and transport capability could also result in the ability to convey water transfers without the need for additional storage south of the Delta in below average and dry years.

Improved Water Supply Availability for Exports in Average Years: There is competition for Bay-Delta water supplies even in average years. Improved export water supplies availability would result from added storage, conjunctive use, groundwater storage, demand management and all other actions that would result in either added supplies or reduced demands.

Improved Water Supply Availability for Exports in Dry Years: Increased export water supplies during dry years would come from the above as well as increased conjunctive use operations, further conservation, land fallowing, and reduced upstream diversions.

Performance Measure: Reduce Water Supply Uncertainty

Objective: **Reduce the uncertainty of Bay-Delta system water supplies to help meet short and long term needs.**



This performance measure reflects the degree of reduction to the uncertainty of Bay-Delta system water supplies to help meet the needs under short-term and long-term conditions.

Geographic Areas

The potential to reduce the uncertainty of Bay-Delta water supplies to meet competing beneficial uses can be divided between the Delta and the export areas.

Scoring Factors

Short-Term Delta Uncertainty: Short-term uncertainty for Delta users results from situations that potentially jeopardize their ability to meet planned needs in the near term. For example, salinity intrusion into the western Delta caused by limited inflow in critical years may force a pump shutdown. An example of an action that could relieve uncertainty in the short-term would be to install temporary barriers, during singular critical years, in the western Delta, to improve water quality for municipal and urban use.

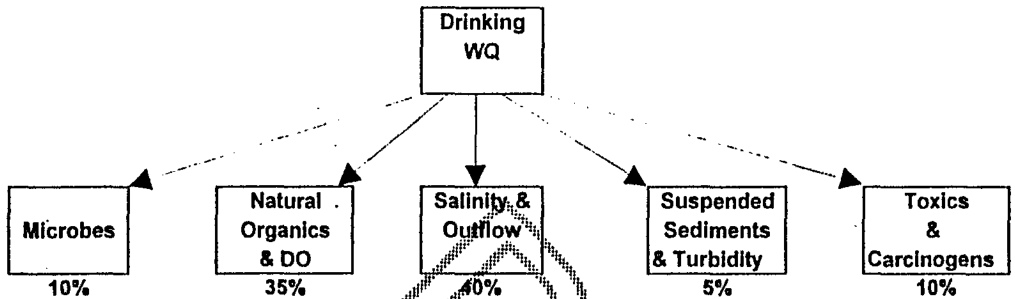
Long-Term Delta Uncertainty: Long-term uncertainty for Delta users results from similar situations that may occur more frequently. An example of a long-term solution would be the permanent relocation of a pump intake to a point minimally affected by salinity intrusion.

Short-Term Export Uncertainty: Short-term export uncertainty would result if water managers were unable to receive planned for water supplies in a single year. An event such as a temporary shutdown of Delta export pumps for ESA reasons or a canal outage could create such a situation. An example of an action that would provide short-term relief would be a the installation of multiple Delta export pumping plant intakes that would allow pumping to continue without violating ESA requirements.

Long-Term Export Uncertainty: Long-term export uncertainty would result if water managers were unable to receive planned for water supplies repeatedly. An example of a long-term solution would be an action that would minimize or eliminate the potential for interruptions in service caused by a similar event (ESA situation) such as improved fish screens at the export intake, or, additional storage south of the Delta.

Performance Measure: Delta Drinking Water Quality

Objective: **Provide good raw water quality in the Delta as a drinking water source (primarily exports) and for body contact recreation.**



This performance measure evaluates the degree to which an alternative would provide adequate export Delta drinking water quality. The performance measure incorporates the CALFED Bay-Delta Program drinking water quality objectives by analyzing the ability of an action to:

- *Reduce concentrations and fluctuations of raw water quality constituents of concern to public health*, especially those that are difficult to remove during treatment using the evaluation criteria listed below,
- Ensure that raw water is treatable to meet existing drinking water standards and those likely to be imposed in the future, and
- *Reduce concentrations of raw water quality constituents that cause taste, odor, or other aesthetic problems.*

Geographic Areas

Land uses in-Delta and in upstream watersheds directly effect the drinking water quality of the Delta; therefore, the performance measure does not geographically divide the water basin, but analyzes the system.

Scoring Factors

Microbial contaminants: Micro-organisms, especially fecal coliform bacteria, viruses, and protozoa, can spread diseases and gastroenteric parasitic infections. Some extremely small (approx. 1um) protozoa can be difficult to remove without multiple barrier protection measures at treatment plants. Unit for measuring benefits may be expressed as reduction in raw water *microbial concentrations* or as reduction of treatment costs from present conditions.

Natural organics: Natural organics, such as algae, decomposing vegetation, and peat soil, can cause poor taste and odor in drinking water, and may react with bromides from saline water and chloride at treatment facilities to produce trihalomethanes (THMs) - a suspected carcinogen. The water basin has a naturally occurring high level of natural organics from the Delta peat soils. Additional treatment is required to meet THM requirements. Unit for measuring benefits may be expressed as reduction in raw water natural organic levels (expressed as THM formation potential carbon - TFPC) from current conditions.

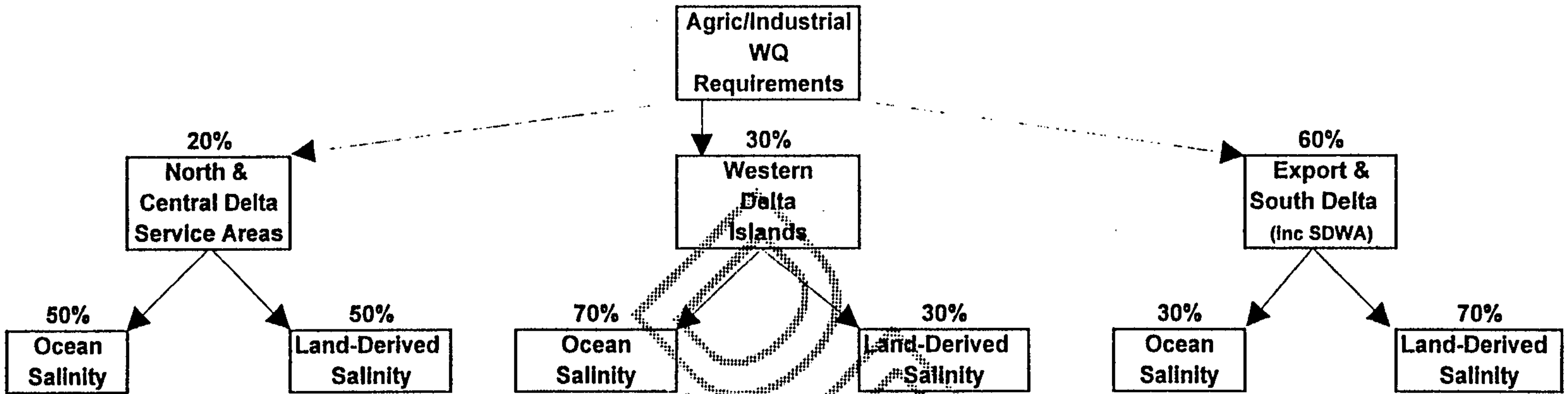
Salinity: High salinity or total dissolved solids (TDS) impairs water taste and increases hardness. Bromides associated with ocean salts can intermix with export water, natural organics, and chloride at treatment plants to produce THMs. Reduction in salinity levels requires additional treatment. Unit for measuring benefits may be expressed as reduction in raw water salinity levels.

Suspended sediments (TSS) and turbidity: The presence of high levels of TSS and turbidity in raw water require additional treatment to improve aesthetics and water clarity. Unit for measuring benefits may be expressed as change in raw water TSS levels or Nephelometric Turbidity Units (NTU).

Toxics and carcinogens: Heavy metals and pesticides are of concern to public health. If present, they require advanced treatment measures. Unit for measuring benefits may be expressed as reduction in microbial concentrations or as reduction of treatment costs.

Performance Measure: Agricultural/Industrial Water Quality Requirements

Objective: **Provide Delta water of sufficient quality to meet agricultural/industrial beneficial uses.**



This performance measure evaluates the capabilities of actions to provide sufficient Delta water quality (locally and exported) to meet agricultural and industrial requirements.

Geographic areas

The three geographic areas of the Delta that impose water quality constraints on agricultural and industrial beneficial uses are the Western Delta, Central Delta (and adjacent Delta service areas) and the Southern Delta, which is the source for the export service areas.

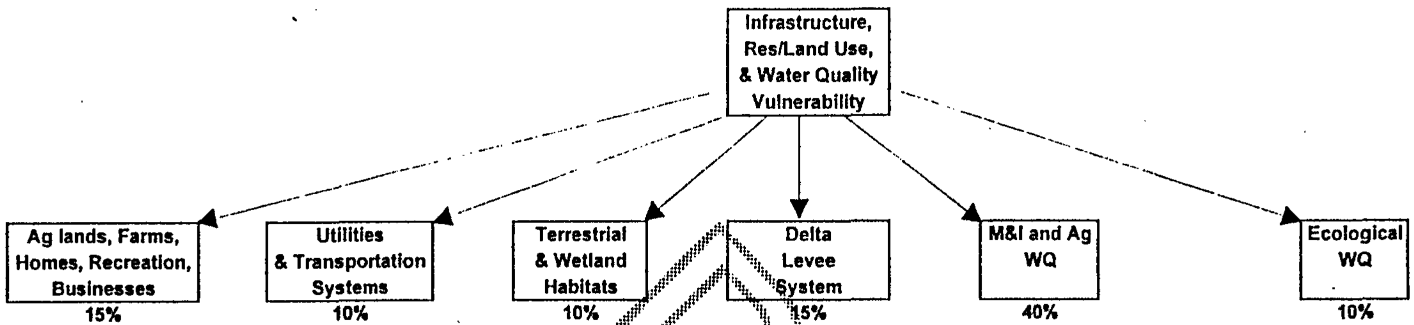
Scoring Factors

Although there are numerous constituents and indicators that can affect these uses, including chlorides, total dissolved solids (TDS), boron, hardness, and sodium (as indicated by the Sodium Absorption Ratio), electrical conductivity has been selected as the most representative measure of impairment. The key component of the performance measure is the ability to reduce electrical conductivity as a measure of total dissolved solids. There are two original sources of these salinity constituents; ocean-derived and land -derived elements and salts.

Degradation of Delta water quality by salts occurs from three primary sources 1) at the brackish upstream end of the estuary (ocean-derived salts), 2) the Delta itself (primarily agricultural drainage from Delta islands), and 3) upstream of the Delta (primarily subsurface agricultural drainage from the San Joaquin Valley).

Performance Measure: Infrastructure, Resource/Land Use, and Water Quality Vulnerability

Objective: **Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.**



This performance measure evaluates capability of Actions to provide adequate protection against potential direct damage and flooding of Delta islands and resources caused by catastrophic floods, high tides, high waves, rising sea level, earthquake, tsunami or further land subsidence. A secondary, but equally catastrophic, potential consequence of a general levee failure (or to a lesser degree, even localized failure) during a low outflow period is a major intrusion of ocean-derived salinity which could contaminate the raw water supply for an extended period.

Geographic Area

The Delta and Suisun Marsh. There is no geographic differentiation for this measure.

Scoring Factors

Key components of the performance measure include ability to protect:

Agricultural lands, farms, homes, recreation and businesses, primarily on Delta lowlands and levees that would be subject to loss, inundation and pre-emption of use due to flooding.

Utilities and transportation systems: Railroads, roads, power transmission lines, and aqueducts located on Delta lowlands, levees, or elevated foundations. These could be subject to direct damage, pre-emption of use by inundation, or foundational weakening, corrosion and decay during extended periods of inundation.

Terrestrial and wetland habitats within the Delta that would be either completely or partially inundated.

Delta Levee System. The Delta levee system network as in-place infrastructure to prevent flooding and pre-emption of land uses, contain channel flows, provide habitat, and provide foundation for certain key roads, buildings, navigational aids, hydraulic control structures, powerlines, etc. Loss of the levee system would necessitate expenditures of major investments of time, money and materials to restore its functionality. Delta-wide catastrophic damage and flooding are the major consequences that could result from widespread levee failures (these could be simultaneous failures or a series of sequential failures radiating from one point, as a result of increased wind fetch, consequent wave size, tidal currents, and resultant damaging erosion).

M, I & Ag water quality: Water quality for municipal, industrial and agricultural beneficial uses, both within the Delta and in the export service areas. Major salinity intrusion caused by a sudden influx of ocean and San Francisco Bay waters could contaminate the water supply for an extended period and require extraordinary releases of freshwater from storage, accompanied by extensive repairs of infrastructure to restore adequate quality to the water supply.

Ecological water quality: Water quality for in-Delta habitats and biological species. Ocean-derived salts could cause major damage to freshwater and brackish marshes, riparian habitats and other wetlands, and agricultural lands. Prolonged flooding with saltwater could necessitate additional flushing and leaching of soils to remove accumulated salts and restore the capacity of the soil to support the desired beneficial uses.